Welcome to ITRC's Internet Training

Thank you for joining us.

Today's presentation is focused on the technical and regulatory guidance document entitled:

"Users Guide For Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells"

Sponsored by ITRC, EPA-TIO, and USGS

Today's Presenters

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Who's Involved?

STATE-LED INITIATIVE WITH:

- ★ 38 States and DC (and growing)
- ★ Sponsoring State Organizations

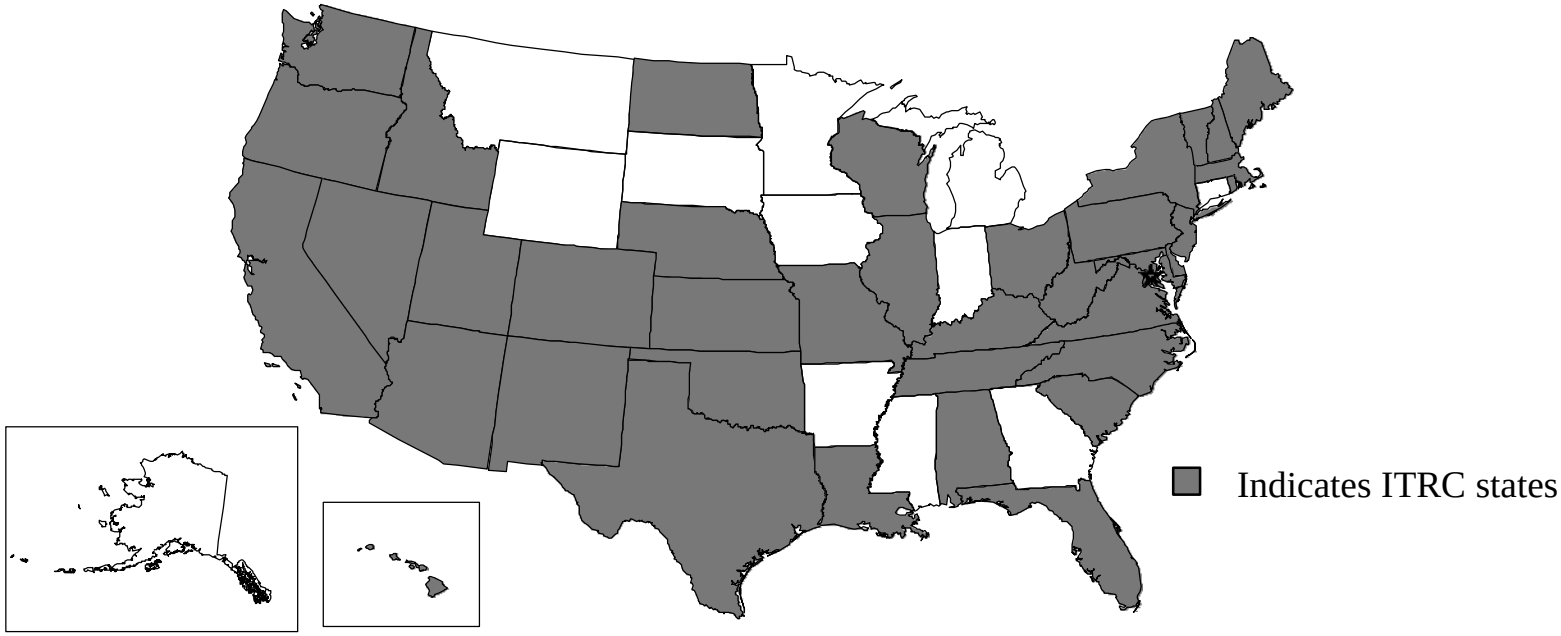
ECOS *Environmental Council of the States*

Western Governors' Association

Southern States Energy Board

- ★ Public/Tribal Stakeholders
- ★ Industry Representatives
- ★ DOE US EPA DOD

Creating Tools and Strategies to Reduce Technical and Regulatory Barriers to the Deployment of Innovative Environmental Technologies



- ★Bioremediation
- ★DNAPLs
- ★In Situ Chemical Oxidation
- ★Permeable Reactive Walls
- ★Radionuclides
- ★Sediments
- ★Small Arms Firing Ranges
- ★In Situ Biodenitrification
- ★Phytoremdiation
- ★Diffusion Samplers
- ★Unexploded Ordnance
- ★MTBE
- ★Perchlorate
- ★Sampling & Characterization

Presentation Overview

- ⋆ Background on diffusion samplers
- ⋆ Theory – Why diffusion samplers work
- ⋆ Question and Answer Period 1
- ⋆ Discussion of User's Guide and practical applications
- ⋆ Data interpretation – comparison between different methods
- ⋆ Regulatory Considerations
- ⋆ Questions and Answer Period 2
- ⋆ Wrap-up and links to additional information and resources

Passive Diffusion Bag (PDB) Samplers

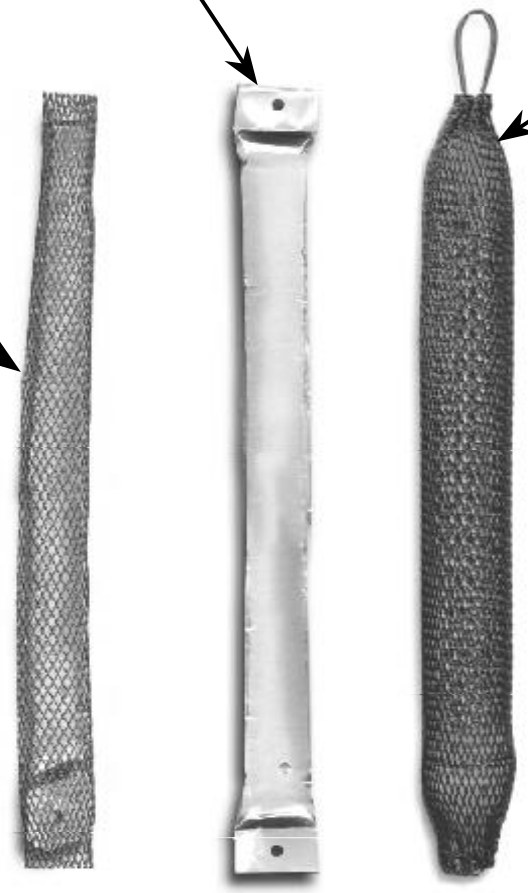
- PDB samplers are used to obtain ambient concentrations of volatile organic compounds (VOCs) in wells.
- Why are they a desirable alternative?
  - Very inexpensive
  - Sampling - rapid and easy
  - Potential to eliminate pumps and reduce waste water
  - Sometimes can provide information difficult to obtain with conventional methodologies
  - Practical for use for access is a problem or discretion is desirable

Typical Water-Filled Diffusion Samplers

PDB sampler without protective mesh

PDB sampler with protective mesh

Must purchase from vendor or obtain license from USGS (703 648:4344)



PDB sampler attached to bailer bottom

Principle

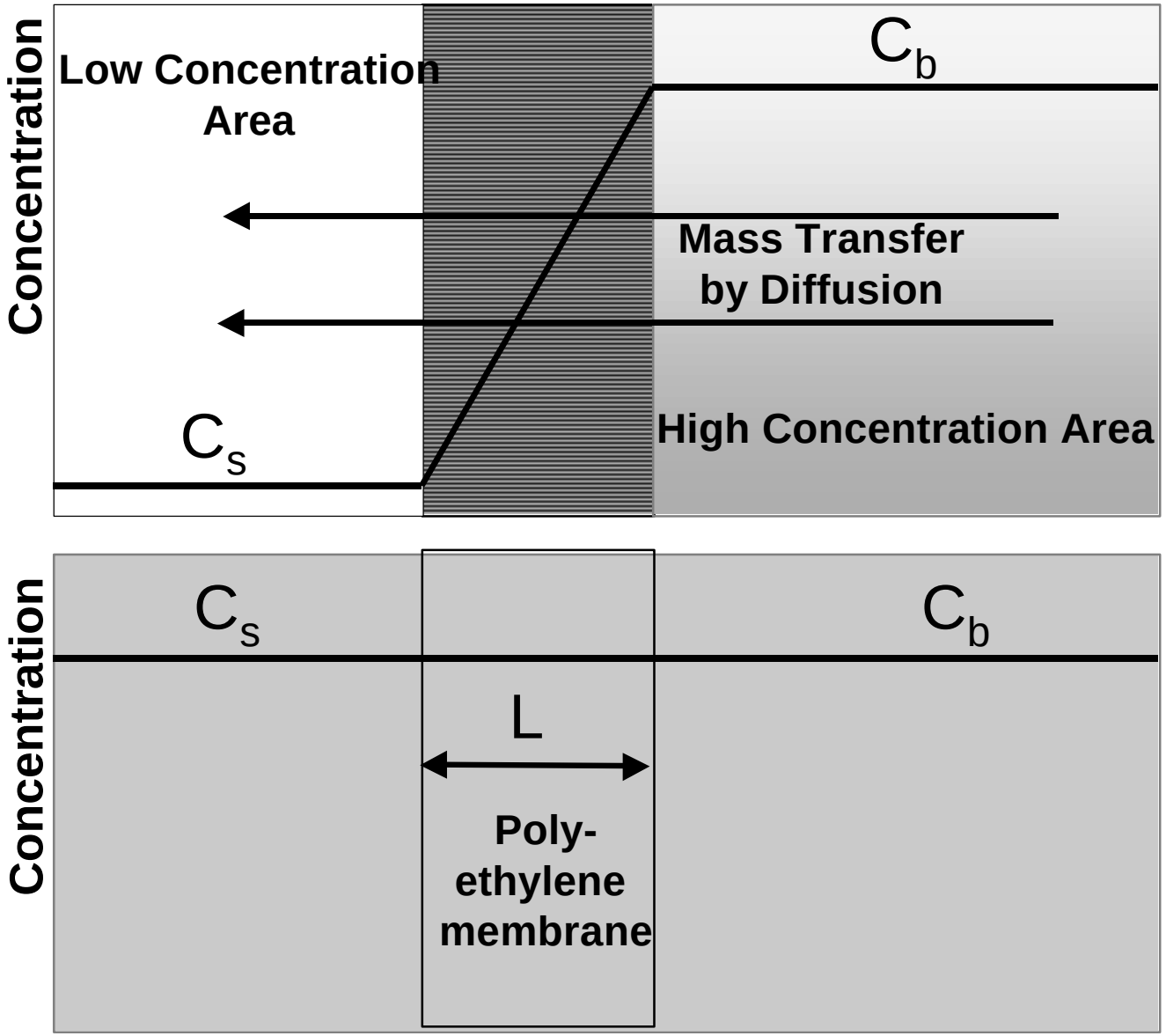
- **Law of Diffusion**
  - Compounds tend to migrate from an area of high concentration to an area of low concentration until equilibrium is achieved

Fick's Law:

- **Fick's Law**
  - The rate of diffusive mass transfer through a unit area (*J*) is proportional to the difference in concentrations (C_1-C_2) divided by the distance separating those concentrations (*L*). The constant of proportionality is also called the diffusivity, or diffusion coefficient (*D*).

Principle

Law of Diffusion (cont.)



Deployment of PDB sampler with attached weight (Eon sampler)

Protective Mesh Sock

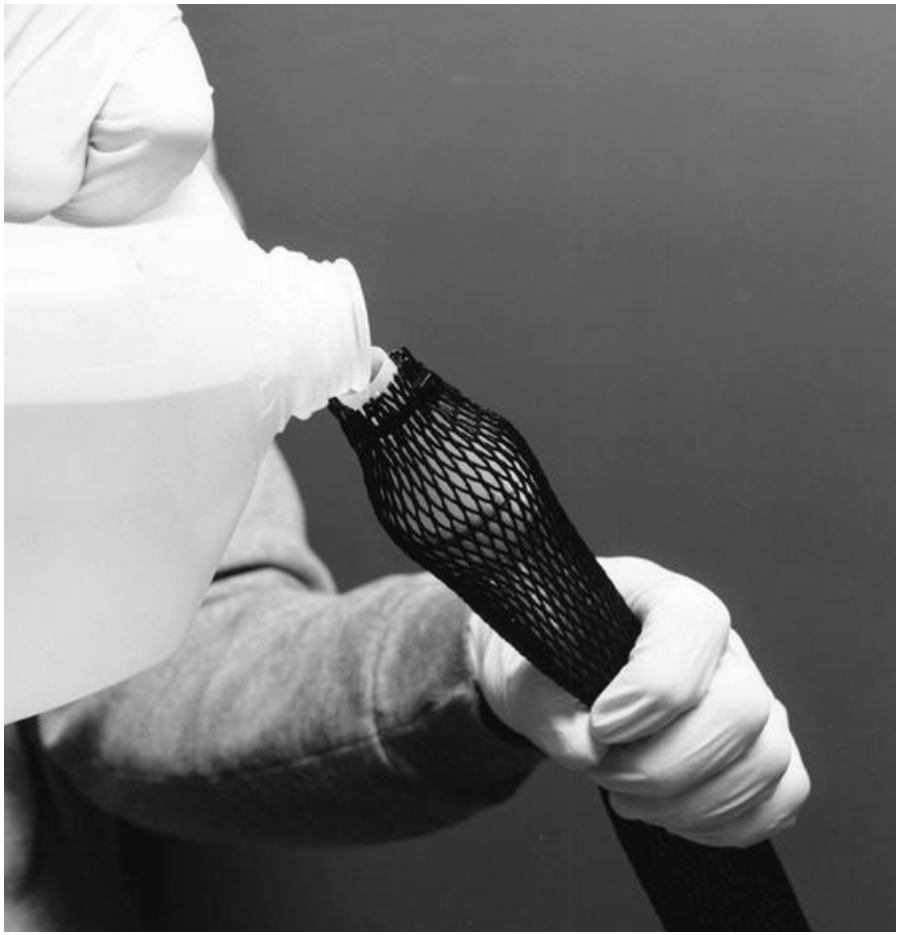
Weight Hanger

Weight

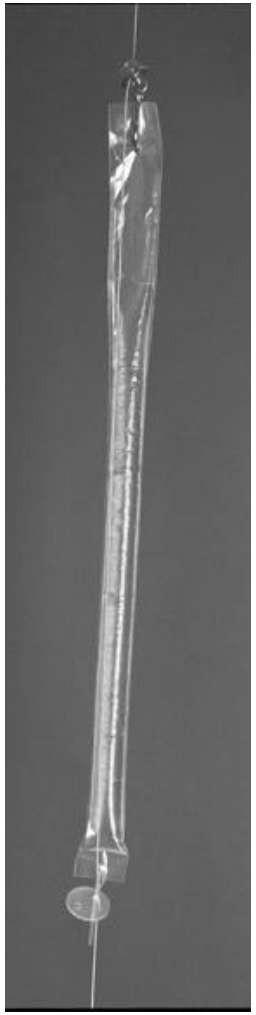
Diffusion Ba (inside mesh sock)

Filling and Sampling Port

Field Filling PDB Sampler



Commercially Available Prefilled PDB Sampler

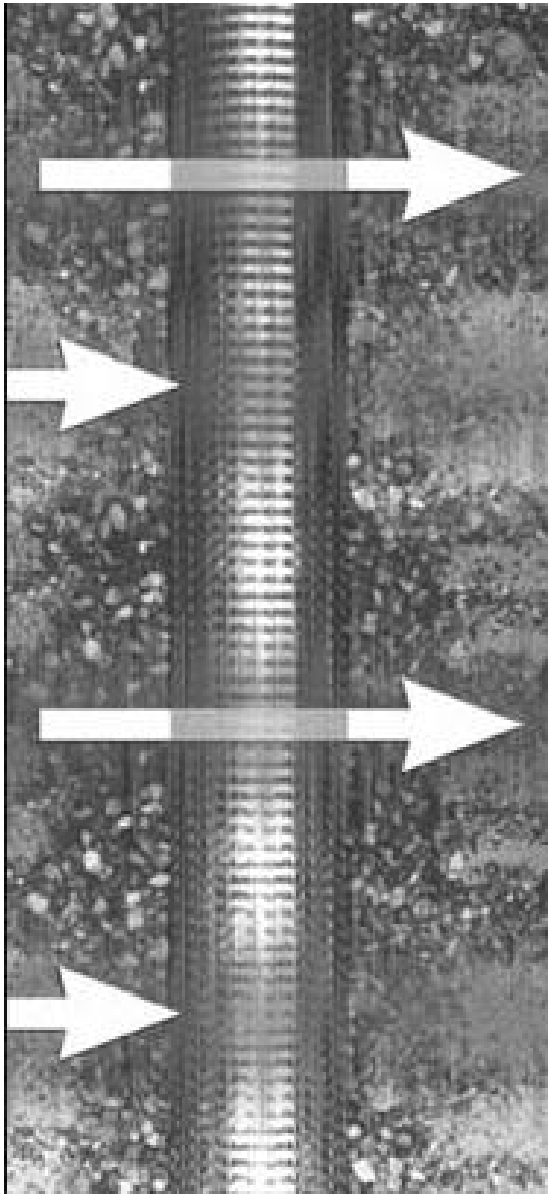


Sampler

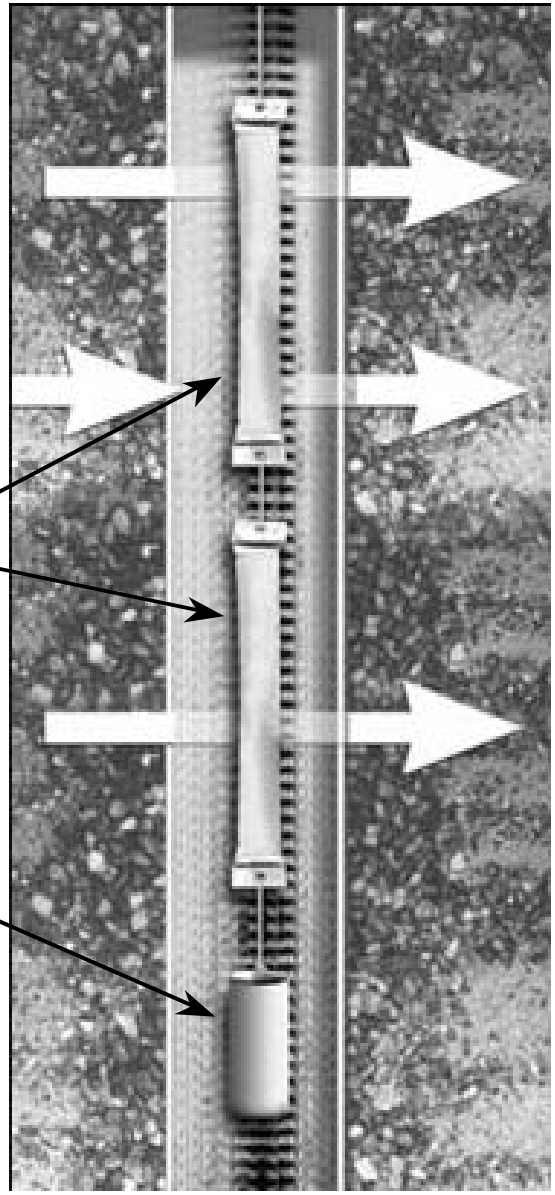
Weight

Groundwater and Contaminant Flow

Cross Section View



Diffusion Samplers Deployed in Well



Diffusion Samplers

Weight

Cross Sectional View

Avg. Diffusion Sampler size 1 to 2 feet in length

Lab Tested VOCs

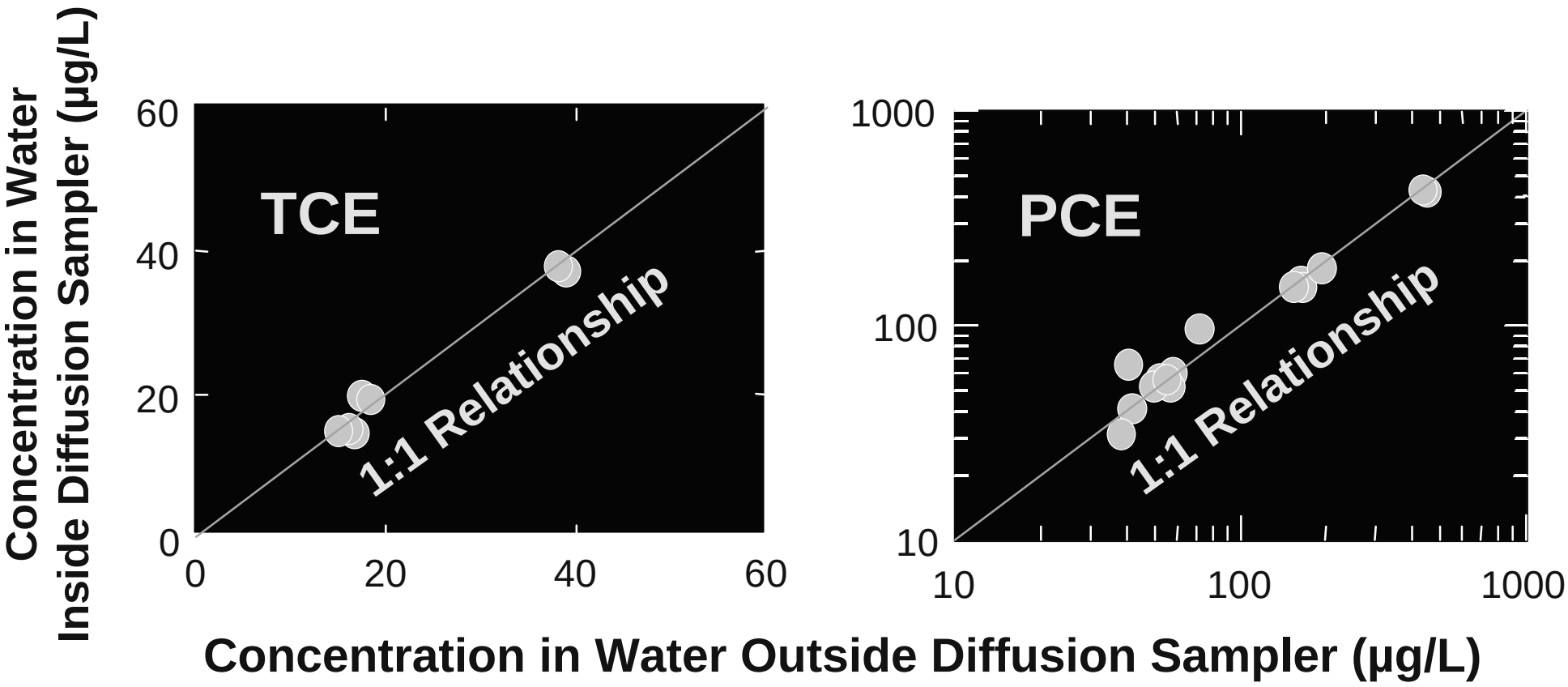
Tested compounds showing good correlation (11 or less percent difference)

Benzene	2-Chlorovinylether	*cis*-1,2-Dichloroethene	1,1,1-Trichloroethane
BDCMethane	DBChloroMethane	*trans*-1,2-Dichloroethene	1,1,2-Trichloroethane
Bromoform	DibromoMethane	1,2-Dichloropropane	Trichloroethene
Chlorobenzene	1,2-DCBenzene	*cis*-Dichloropropene	TCFMethane
Carbon Tet.	1,3-DCBenzene	EDB	1,2,3-TCPA
Chloroethane	1,4-DCBenzene	*trans*-1,3-DCPE	1,1,2,2-PCA
Chloroform	DCFMethane	Ethyl benzene	Tetrachloroethene
Chloromethane	1,2-Dichloroethane	Naphthalene	Vinyl chloride
	1,1-Dichlorethene	Toluene	Xylenes

Tested compounds showing poor correlation (> 20 percent difference)

Acetone*	MTBE	Styrene	MIBK*

Lab Tests of Water-Filled Diffusion (PDB) Samplers



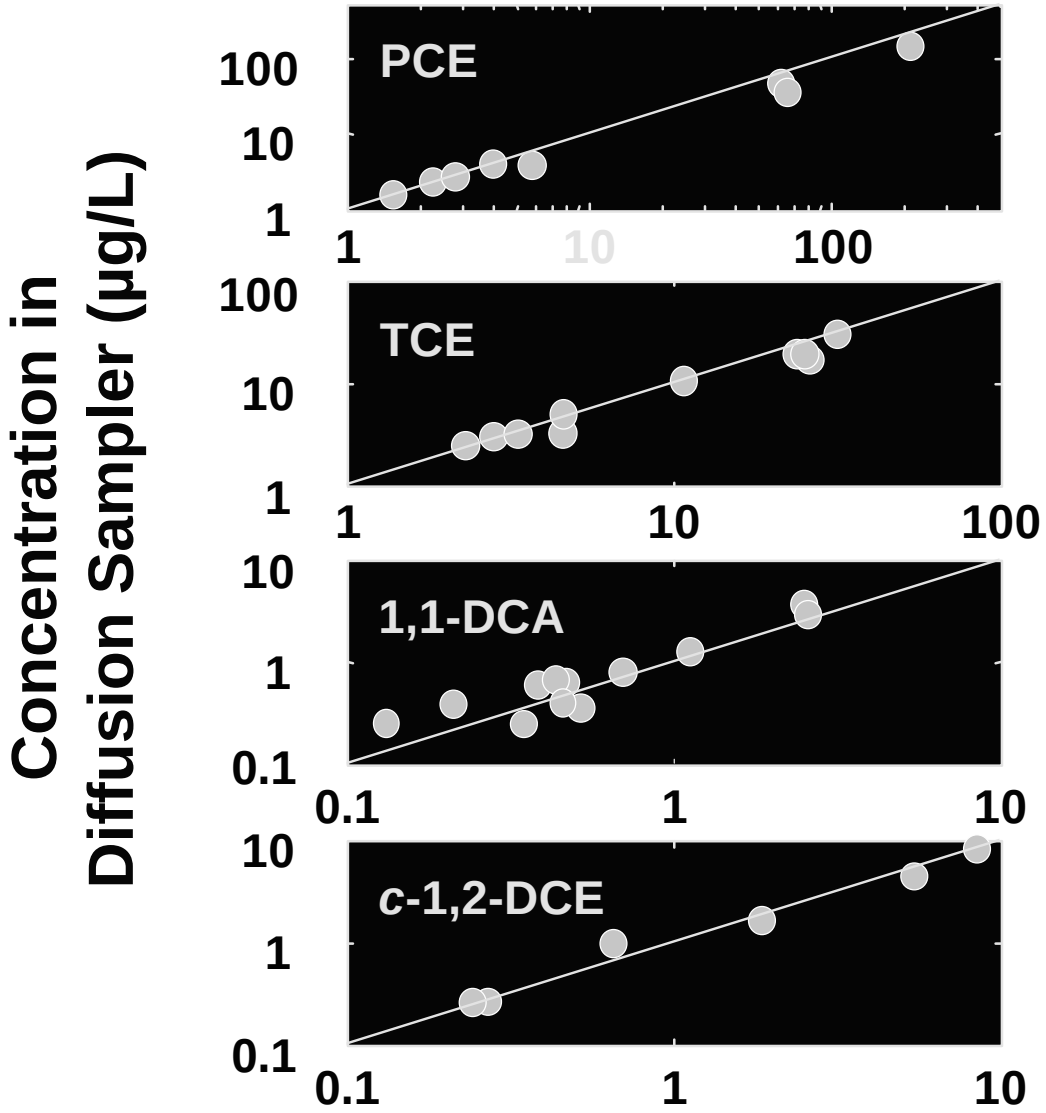
Conventional Well Sampling Methods

Two standard methods

- ⋆ Purge-and-Sample
  - Remove 3 or more casing volumes of water prior to collecting a sample

- ⋆ Low-Flow (LF) or Low-Volume Sampling
  - Slowly purge with no drawdown until field parameters stabilize prior to collecting a sample

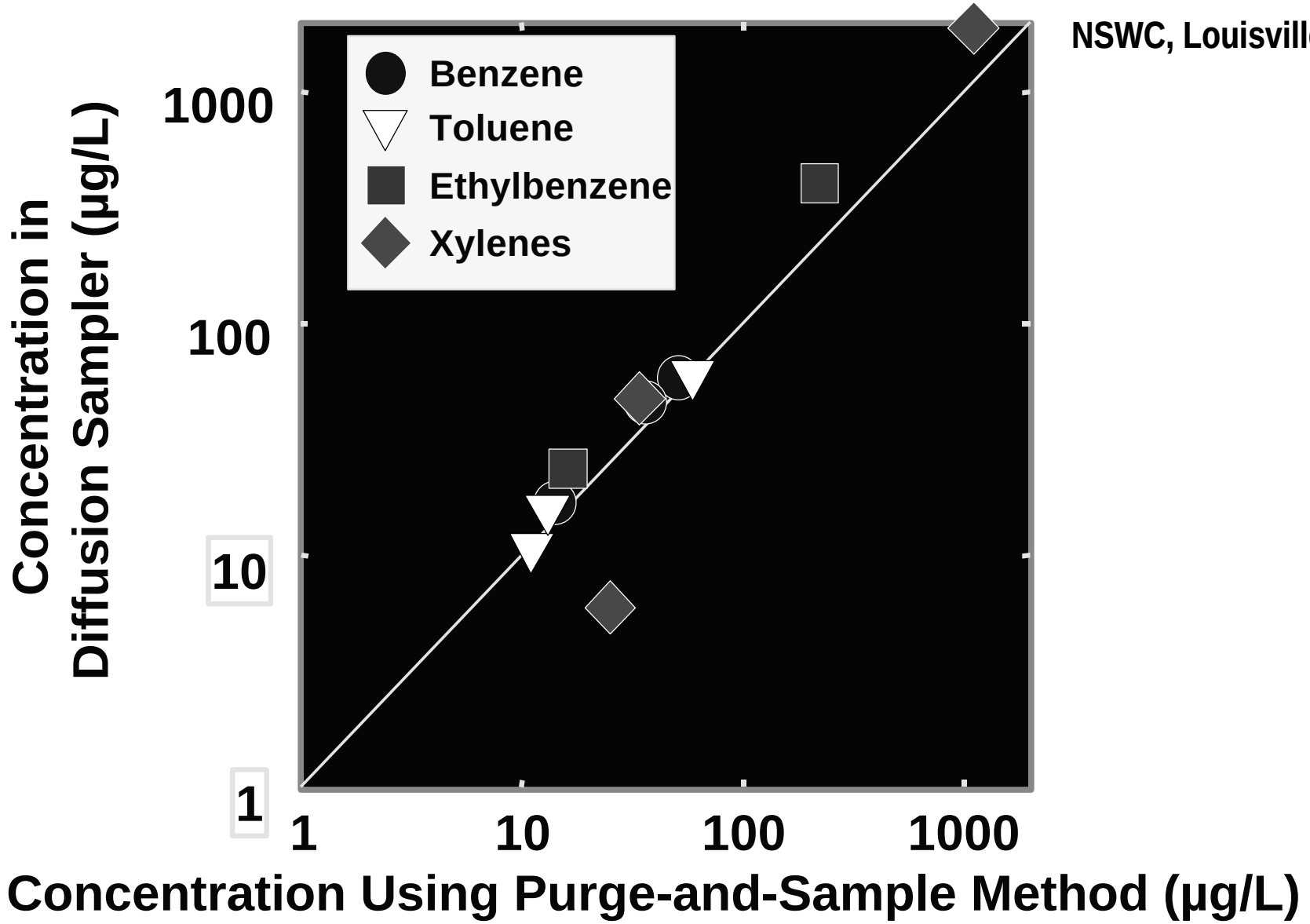
Diffusion vs. Purge-and-Sample under Field Conditions



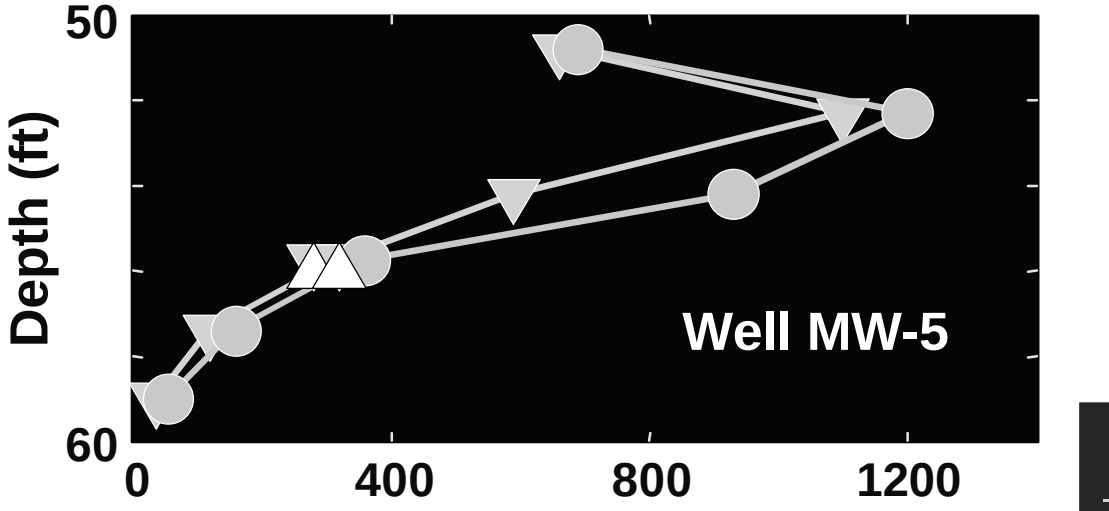
Davis, CA (Jan. 1999)

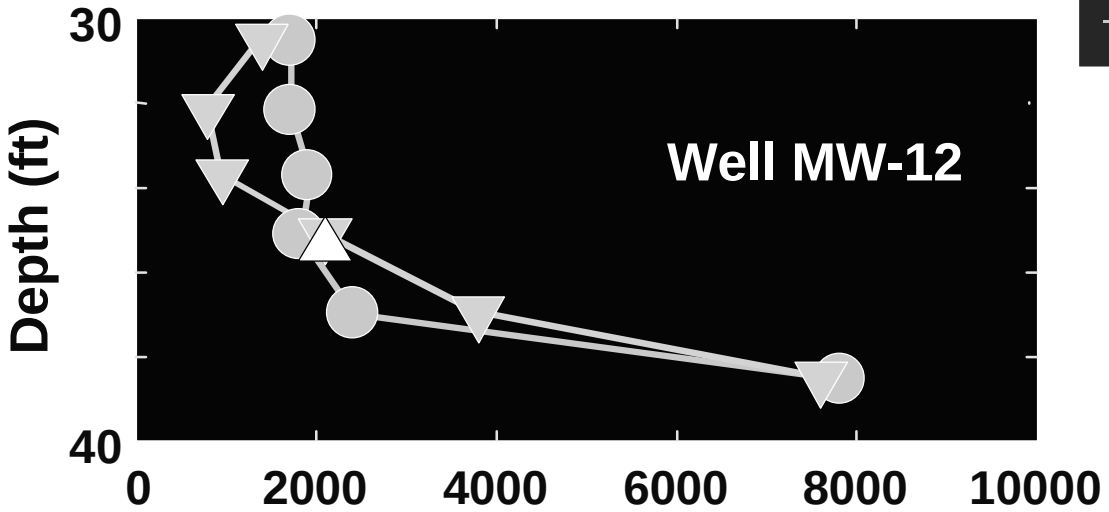
BTEX Data From Fractured-Rock Aquifer

NSWC, Louisville, KY



TCE Stratification in 10-Ft Well Screens

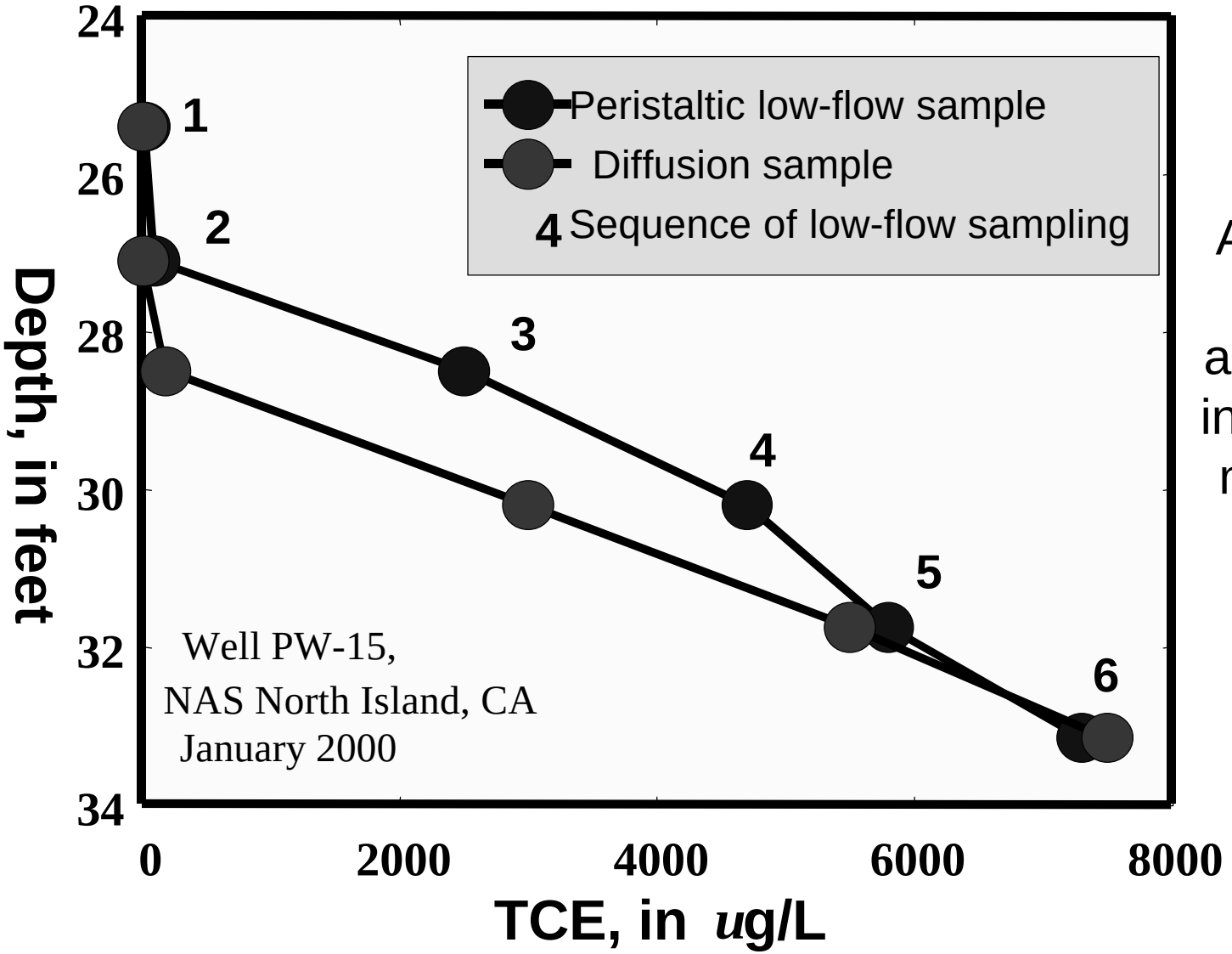




LF bladder pump
LF peristaltic pump
Diffusion sample

NAS North Island, CA

Low-flow Sampling effects near TCE stratification



As the sequential low-flowing sampling approaches a chemica interface, in-well mixing may obscure the TCE profile

Comparison of PDB and Purge Sampling Methods at Well 18S (deployment of single PDB sampler in approximate center of screened interval)

	PDB Sampler Method (µg/L)	Purge-and-Sample Method (µg/L)
Total 1,2-DCE	130	650
TCE	570	2,300

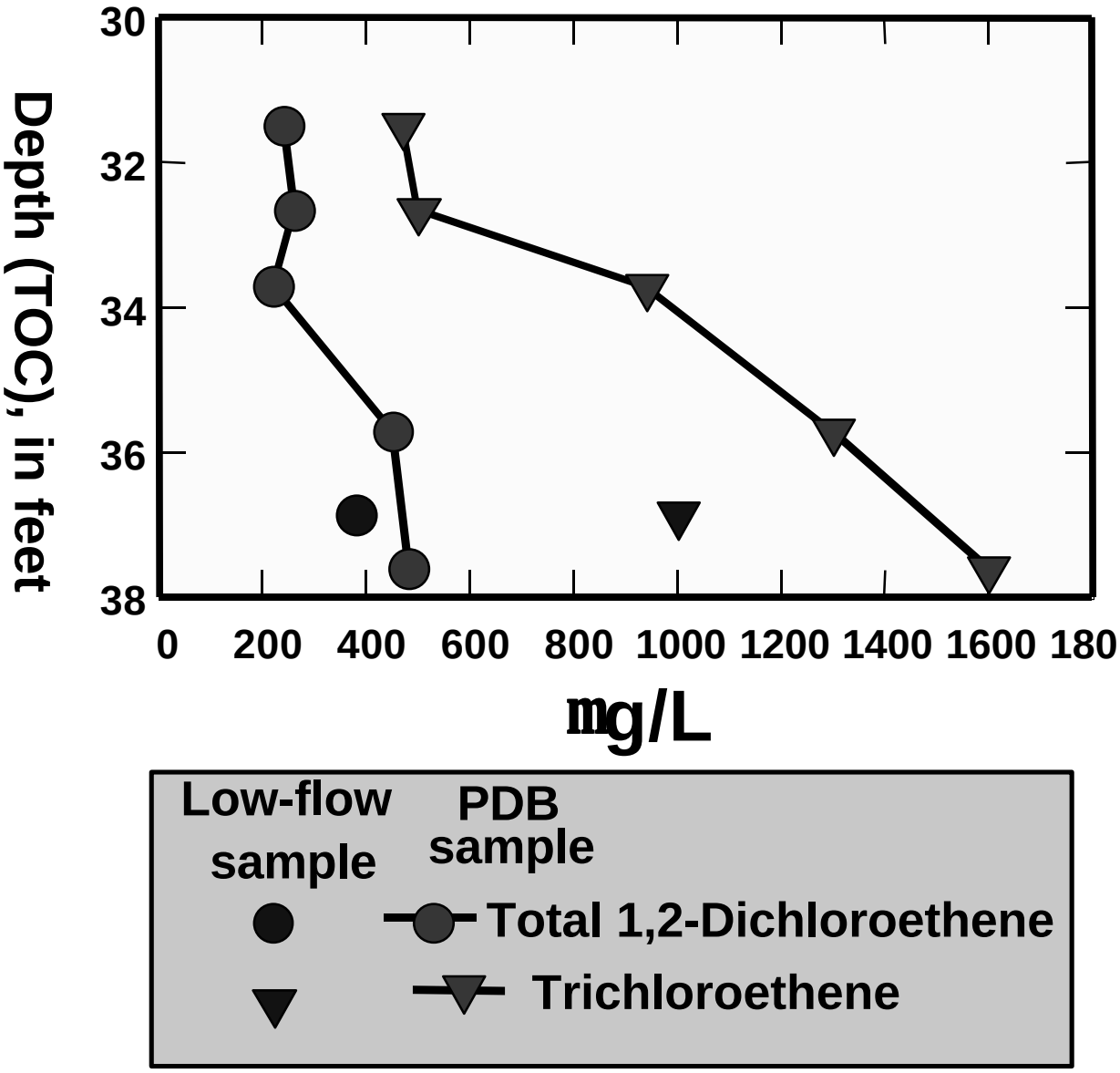
4-casing-volume purge

Fridley, MN (Nov. 1999)

Multiple Diffusion Samplers

Switched to Multiple PDB samplers and Low-Flow Sampling at Well 18S

- These data imply that the low-flow sampling results can be a mixture of waters within the screened interval



Fridley, MN (May 2000)

Varying degrees of mixing during sampling

- Thus, diffusion samplers typically constitute a point sample. Useful for targeting the high concentrations. Avg. concentrations for a screened interval are obtained by multiple samplers.

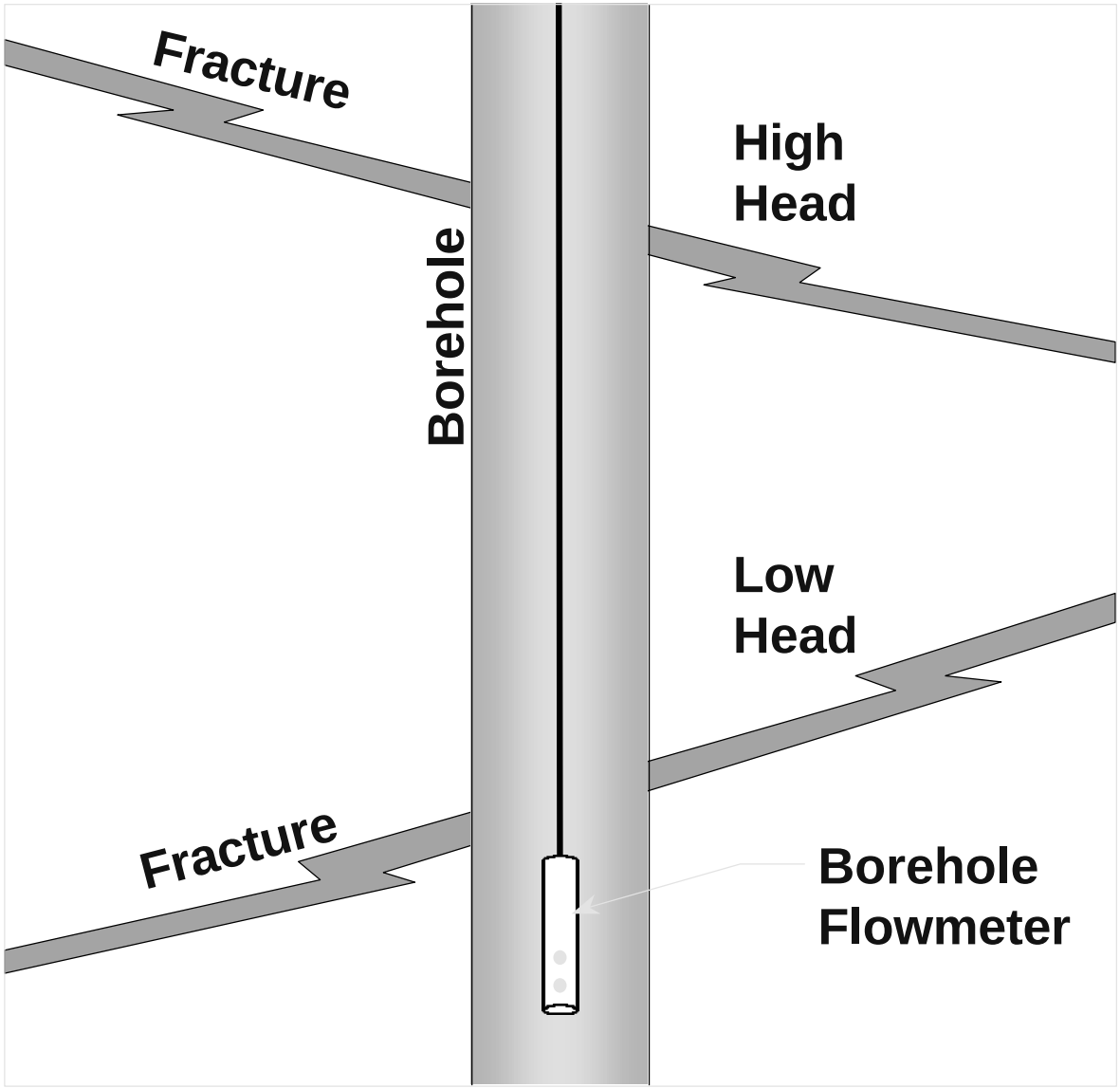
- Low-flow samples sometimes constitute an approximate point sample (selected horizons at NAS North Island) providing no information on average concentrations in a well screen. In other wells, LF samples constitute a mixed sample over varying intervals.

- 3 or more casing-volume purge sampling averages aqueous concentrations even more by mixing, sometimes inducing flow from horizons not in the vicinity of the well screen.

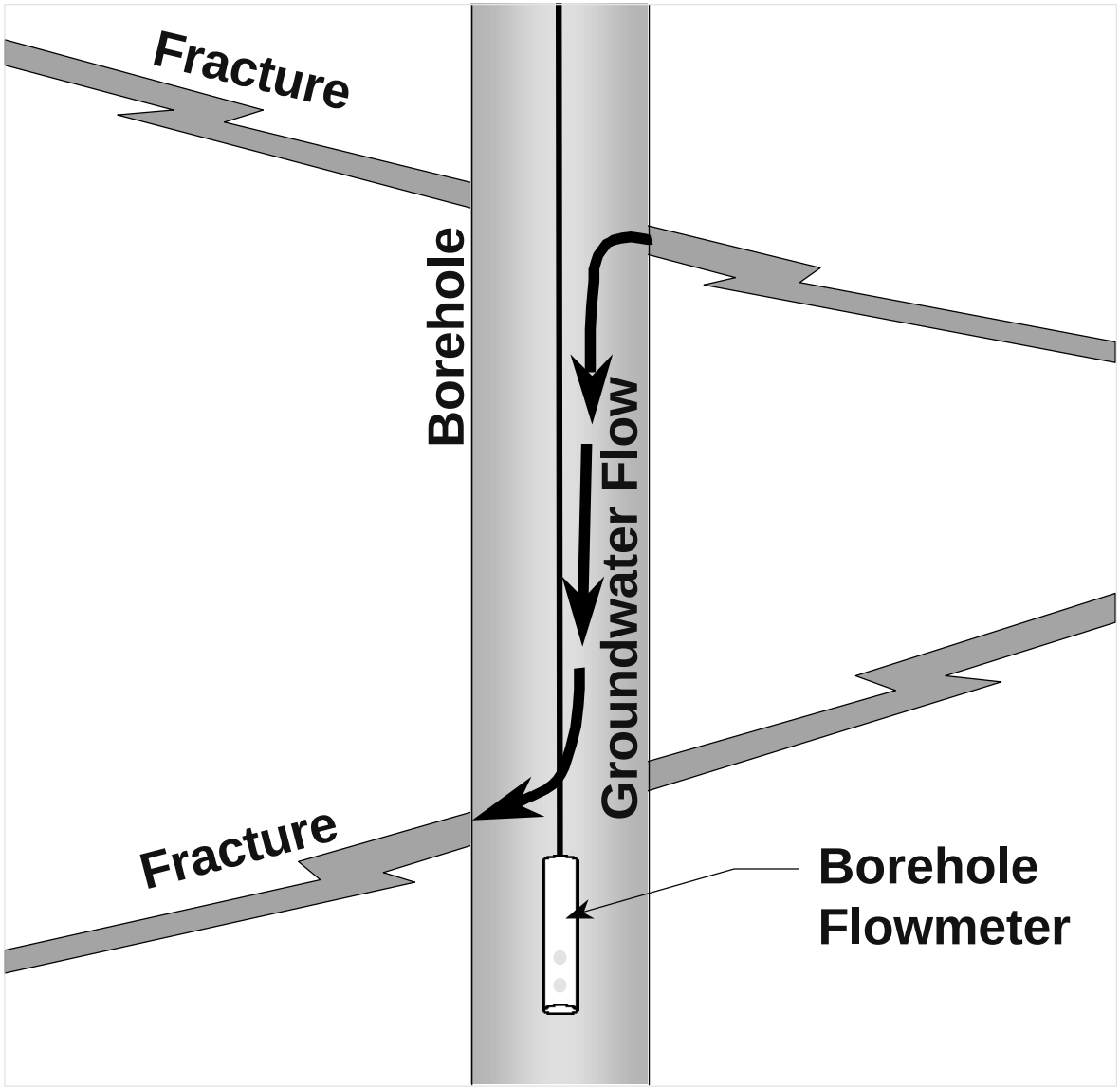
Relation between well sampling and well construction

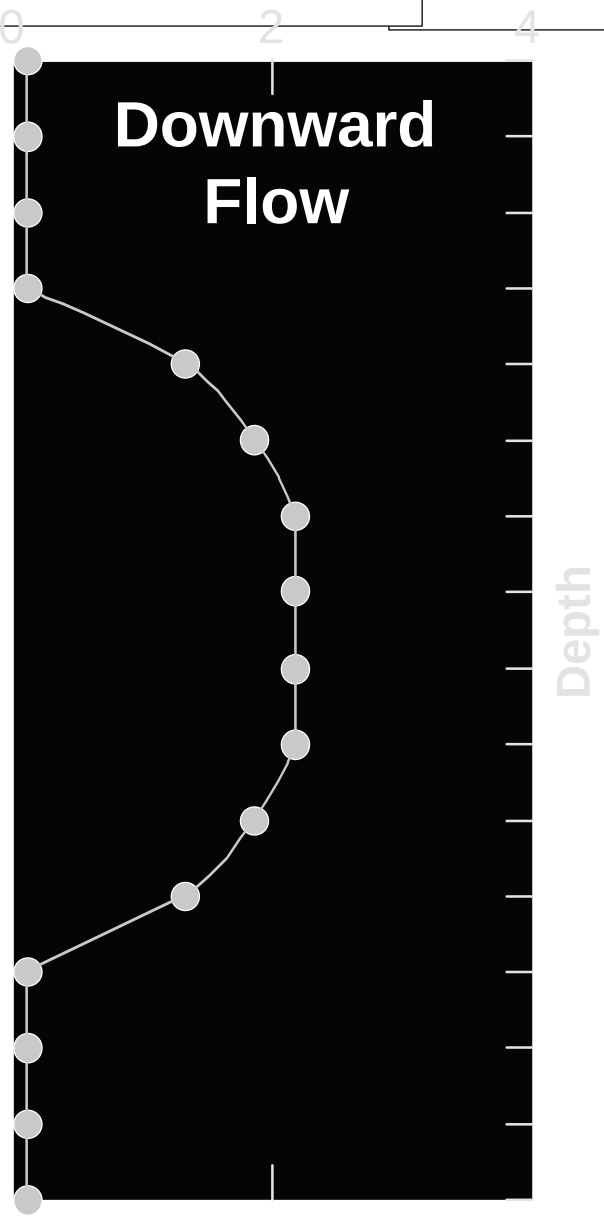
- ⋆ In some cases, VOC stratification in a well and disagreement between sampling methods can result from inadequate wells.
- ⋆ Examples include wells that connect zones of significantly different hydraulic head or contaminant concentration.
- ⋆ CONSIDER THE FOLLOWING EXAMPLES:

Heat-Pulse Flowmeter

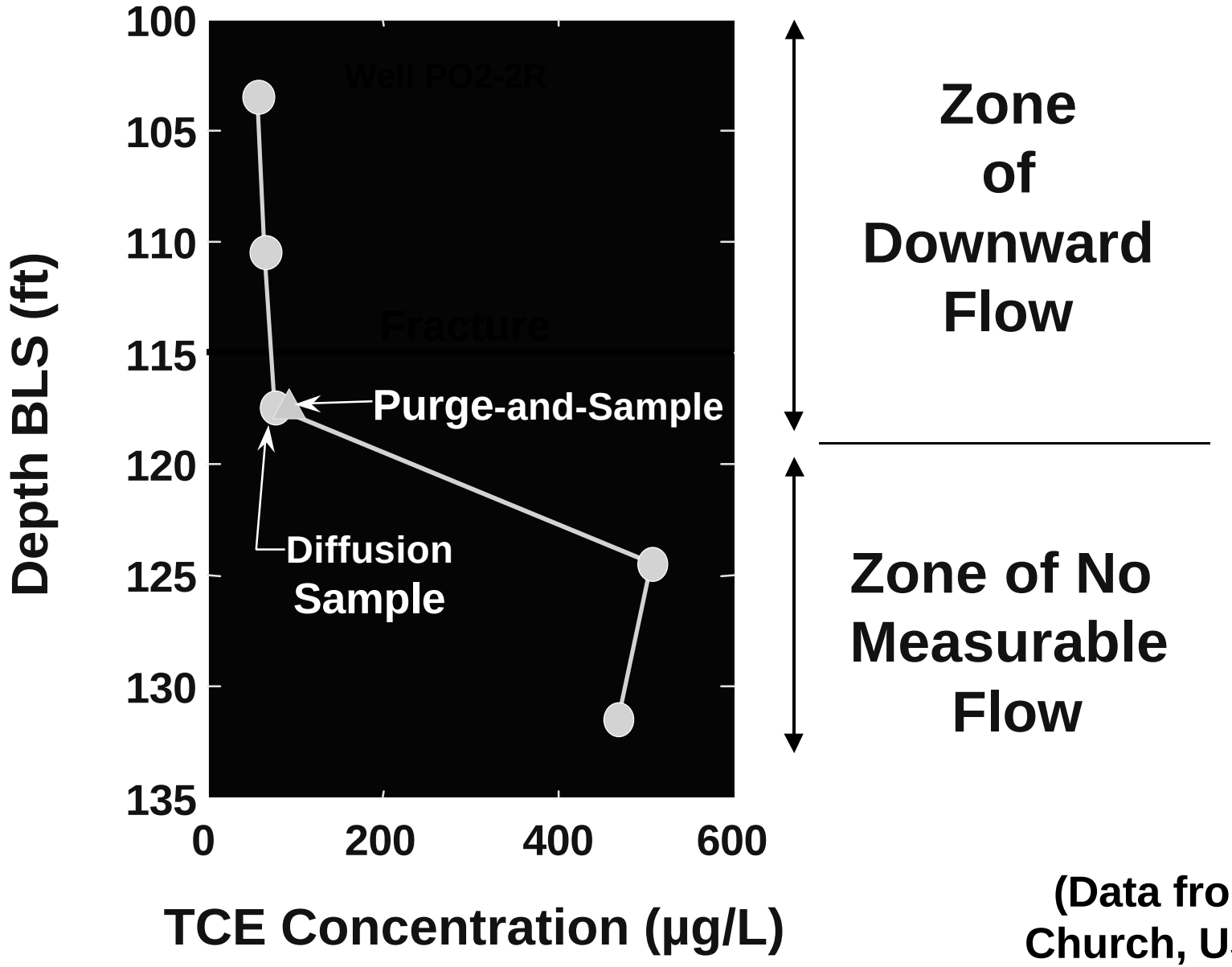


Heat-Pulse Flowmeter





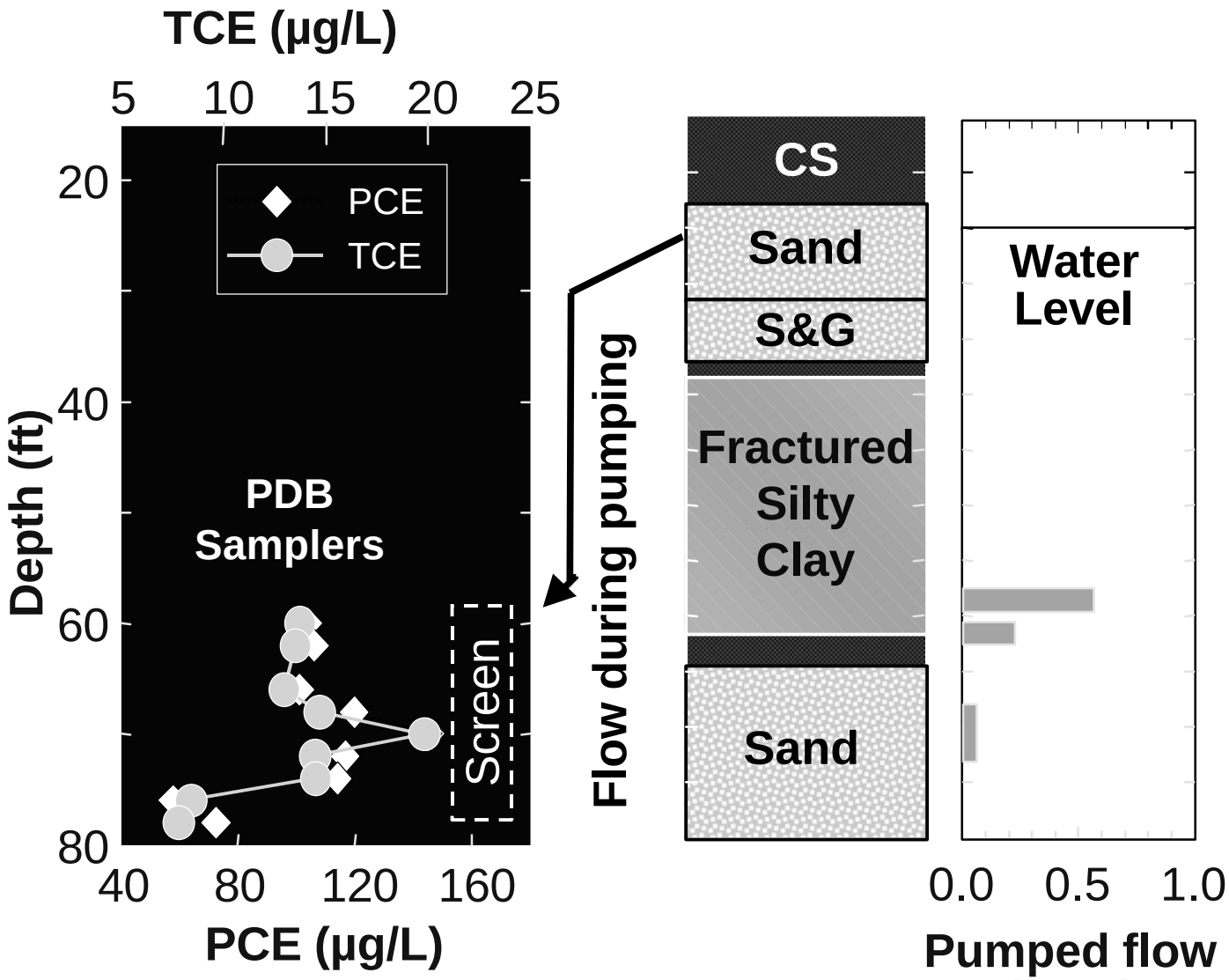
High TCE Concentrations in the Zone of Stagnation



(Data from Peter Church, USGS, CT)

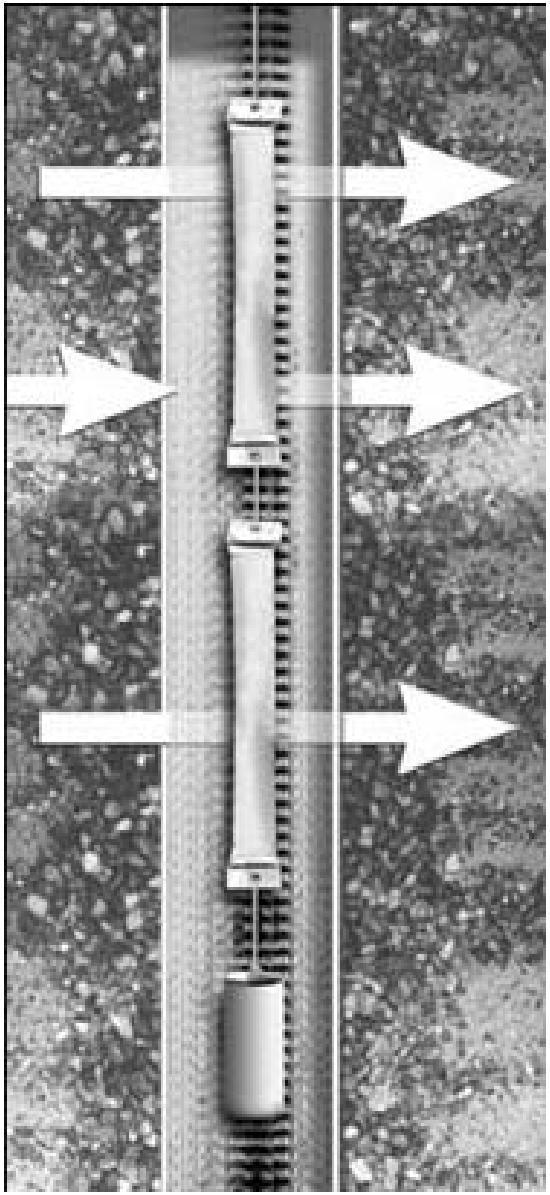
Differing Source Waters for PDB and Purge Methods

- ⋆ Low-permeability aquifer
- ⋆ VOCs were higher in purged sample than in PDB sample.
- ⋆ PDB samples were local. Pumped sample was from above the screen.



(Davis Global Comm., CA,: Well DMW-5)

Questions and Answers



"Users Guide For Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells"

Available for download from:

In the links page at the end of this presentation

OR

http://www.itrcweb.org

http://www.frtr.gov

Mulit-Agency Document

- ⋆ U.S. Geological Survey
- ⋆ U.S. Air Force
- ⋆ U.S. Naval Facilities Engineering Command
- ⋆ U.S. EPA
- ⋆ Federal Remediation Technologies Roundtable
- ⋆ Defense Logistics Agency
- ⋆ U.S. Army Corps of Engineers
- ⋆ Interstate Technology Regulatory Cooperation Work Group (ITRC)

PDB Sampler User's Guide. Part 1

- **Executive summary**
- Introduction
  - Summary of limitations and advantages
- PDB sampler deployment
- Sampler and sample recovery
- Determining applicability
  - Influences of hydraulic and chemical heterogeneity on sample quality
  - Comparison of PDB sampling to conventional methodologies
- Quality control and assurance
- Summary
- References

PDB User's Guide Part 2: Field Tests

- ⋆ Diffusion sampler evaluation of chlorinated VOCs in groundwater (Tunks and others)
- ⋆ NAS North Island, CA (Vroblesky and Peters)
- ⋆ Davis Global Communication, CA (Vroblesky and others)
- ⋆ NIROP Fridley, MN (Vroblesky and Petkewich)
- ⋆ Hanscom AFB, MA (Church)
- ⋆ McClellan AFB, CA (McClellan AFB EMD) (summary only)

User's Guide Part 2: Field Tests

- ⋆ Comparison to purge-and-sample
  - Davis Global Commun., CA (Vroblesky and others)
  - McClellan AFB, CA (McClellan AFB EMD)
  - NIROP Fridley, MN (Vroblesky and Petkewich)
- ⋆ Comparison to low-flow sampling
  - NAS North Is., CA (Vroblesky and Peters)
  - Hanscom AFB, MA (Church)
  - NIROP Fridley, MN (Vroblesky and Petkewich)
- ⋆ Comparison to a variety of methods
  - (Tunks and others)

Advantages of PDB Samplers

- ⋆ Eliminate or reduce the amount of sampling purge water
- ⋆ Inexpensive
- ⋆ Easy to deploy and recover
- ⋆ Disposable, so no equip. decon. is needed between wells
- ⋆ Minimal amount of field equipment is required
- ⋆ Sampler recovery is rapid and practical for use where access is a problem or where discretion is desirable
- ⋆ Can provide information on contaminant stratification
- ⋆ Samplers are not subject to interferences from turbidity

Costs

- ⋆ Typical cost: $16.50 to $22 per sampler
- ⋆ McClellan AFB Study (McClellan AFB)
  - Cost savings for diffusion sampling estimated at several hundred thousand dollars for FY 2001
- ⋆ Parsons Engineering Study (McClellan AFB)
  - Estimated cost per sample:
    - $65 for PDB sampling
    - $555 for the DMLS sampling
    - $308 for micropurge sampling
    - $444 for conventional-purge sampling
- ⋆ USGS Study (Hanscom AFB)
  - Estimated cost per sample:
    - $44 for PDB sampling
    - $72 for low-flow sampling

Limitations of PDB Samplers

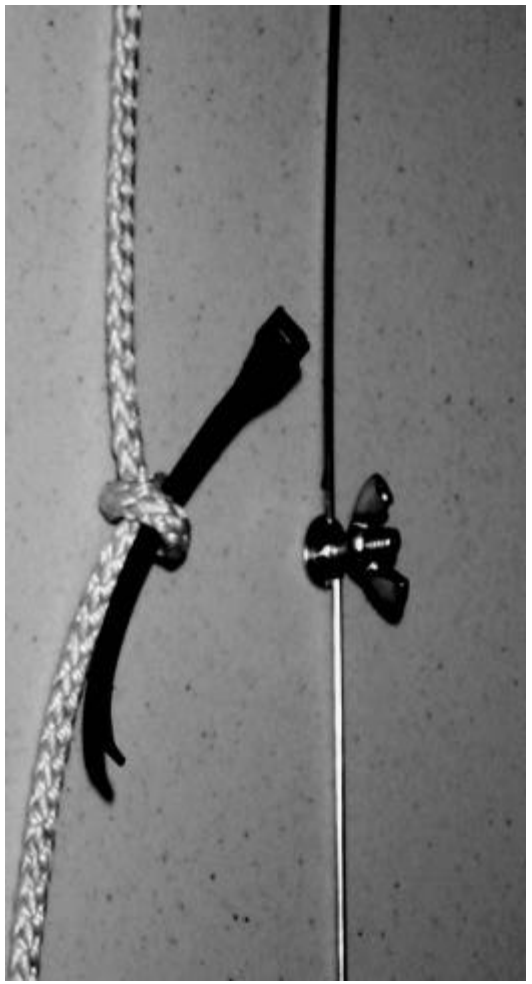
- ⋆ PDB samplers integrate concentrations over time.
- ⋆ Not appropriate for some compounds
  - i.e. MTBE, acetone, most semi-volatiles, most ions
- ⋆ Rely on water movement through the well
- ⋆ Constitute point samples
  - not necessarily a disadvantage

Typical Applications of PDB Samplers

- ⋆ Long-term monitoring of VOCs in wells
- ⋆ Delineating contaminant stratification
  - This information can aid in site characterization
  - More accurate identification of the contaminated horizon can be an aid in optimizing remediation by allowing more accurate targeting by the remediation effort.

Methods of Attaching PDB Samplers to the Line or Weight

- The PDB sampler can be attached to the weighted line by a variety of methods.
  - Wire ties through a knot
  - Stainless steel clamp
  - Direct attachment to the weigh
- Nonbuoyant nonstretch rope can be used as the line, however, stainless steel line is preferable
- Sufficient weight should be added to counterbalance the buoyancy of the PDB samplers



Two Approaches to Measuring the Line to Determine the PDB Attachment Point

- ⋆ Weight suspended above the well bottom
  - Measure the line and attach the PDB sampler at a distance corresponding to the depth of the target zone
  - Be careful that the line doesn't slip or stretch
- ⋆ Rest weight on the well bottom
  - Attach the PDB sampler to the line at a distance from the bottom of the weight equal to the distance from the well bottom to the target horizon
  - Usually this involves less measuring than measuring the line from the top down.

Things to Consider When Measuring From the Bottom Upward

- Measure the well depth
  - Compare measured and reported (from well logs) depths to the well bottom
  - This is to check on whether
    - sediment has accumulated in the bottom of the well,
    - there is a non-screened section of pipe (sediment sump) below the well screen, and
    - on the accuracy of well-construction records.
- If there is an uncertainty regarding length or placement of the well screen, then an independent method, such as video imaging of the well bore, is strongly suggested.

Consider the Screen Length Deploying PDB Samplers

- ⋆ Screen length/saturated interval 5 ft or less
  - PDB sampler in the center
- ⋆ Screen length 5-10 ft
  - Advisable initially to use multiple PDB samplers to ascertain the presence of contaminant stratification
- ⋆ Screen length >10 ft
  - Only use in conjunction with borehole flow meters or other techniques to characterize vertical variability in hydraulic conductivity and contaminant distribution or use strictly for qualitative reconnaissance purposes

PDB Sampler User's Guide. Part 1

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  - Influences of hydraulic and chemical heterogeneity on sample quality
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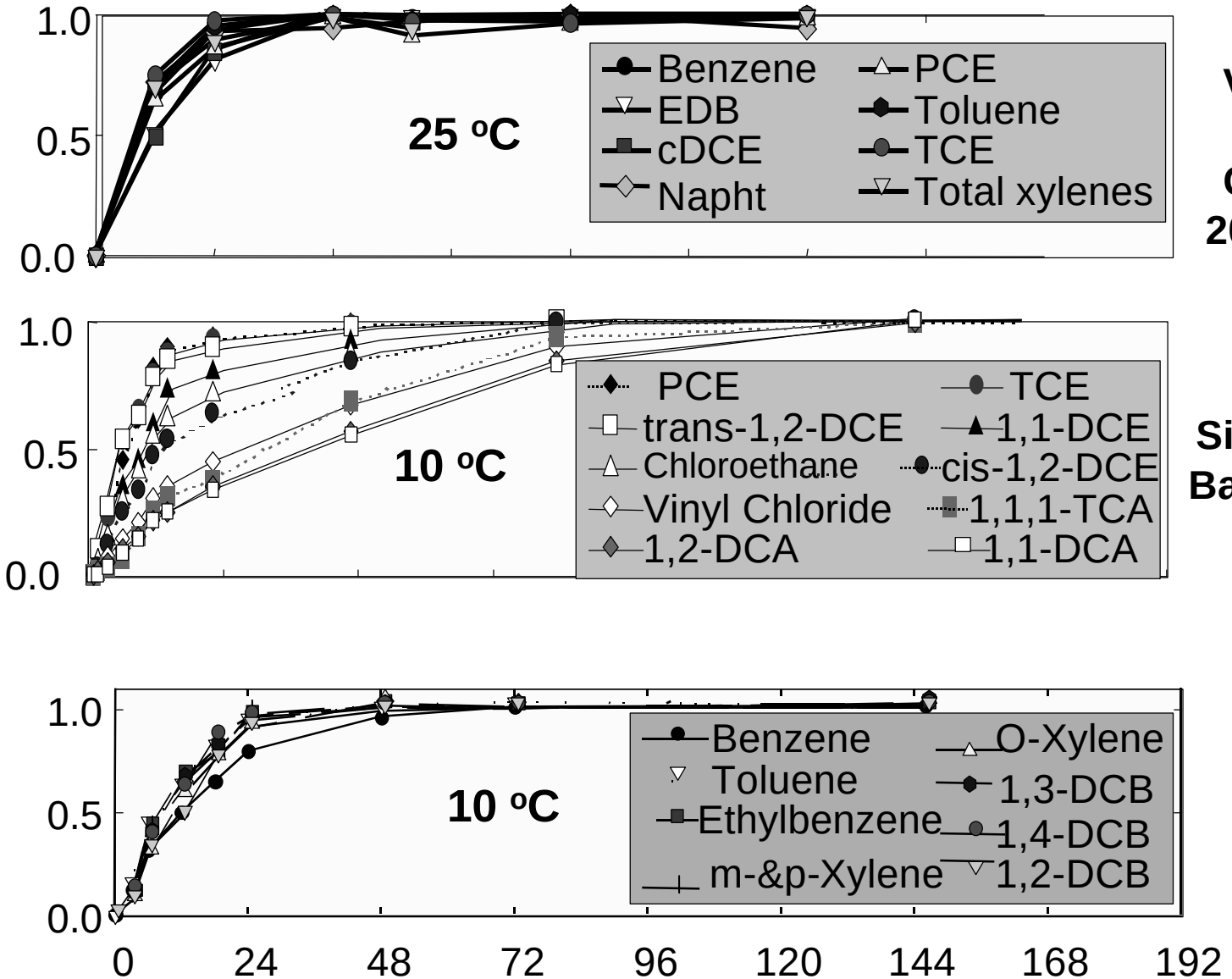
- ⋆ Summary
- ⋆ References

Equilibration of selected compounds in PDB samplers



Vroblesky and Campbell, 2000, USGS

Sivavec,and Baghel 2000 GE Co.

Sivavec, 2001, GE Co.

PDB Sampler Equilibration in Lab Studies

- 48 hours for TCE and several tested compounds at 25 C (Vroblesky, 2000, USGS)

- 93 to 166 hours for VC and some chloroethenes and 48 to 72 hours for BTEX compounds and selected dichlorobenzenes at 10 C (Sivavec and Baghel, 2000, 2001 General Electric Company)

- **But samplers should equilibrate long enough for well water, contaminant distribution, and flow dynamics to restabilize (2 weeks for permeable formations, possibly longer for poorly permeable formations)**

One water-transfer method is to insert a discharge tube through the polyethylene

Inserting the tube through the polyethylene into the PDB sampler

Transferring water to a VOA vial

Attaching a Bottom-Discharge Device

Water Also can be Removed Simply by Cutting the Sampler Open and Gently Pouring into VOA Vials

Determining applicability of PDB Samplers

- ⋆ Common approach is to do a side-by-side comparison to conventional technology
  - Particularly important in wells with high temporal chemical variability

- ⋆ In Wells with low temporal chemical variability, comparison of PDB-sampler results to historical concentrations may be adequate.

Data Evaluation

- In general, if the results agree in a range deemed acceptable by local, state, and Federal regulatory agencies and meet the site-specific data-quality objectives, then a PDB sampler may be approved for use in that well to monitor ambient VOC concentrations.

If PDB-sampler VOC concentrations are higher than VOC concentrations from the conventional method

- ⋆ Then the PDB sampler probably adequately represent ambient conditions
  - This is because there is a greater potential for dilution from mixing during sampling using conventional technology

If the conventional method VOC concentrations are higher than PDB-sampler VOC concentrations – then:

- ⋆ Uncertain whether the PDB sampler or the conventional sampler conc.'s represent local conditions.
  - Further testing (borehole flowmeter and/or multiple PDB samplers) can be used to clarify the situation.
- ⋆ PDB samplers may be more locally representative if the pumped samples
  - Mixed chemically stratified zones
  - Incorporated water containing higher concentrations from other areas not adjacent to the screened interval
    - ➢ along inadequate well seals
    - ➢ through fractured clay

The decision on whether to use PDB samplers in such situations depends on the data quality objectives

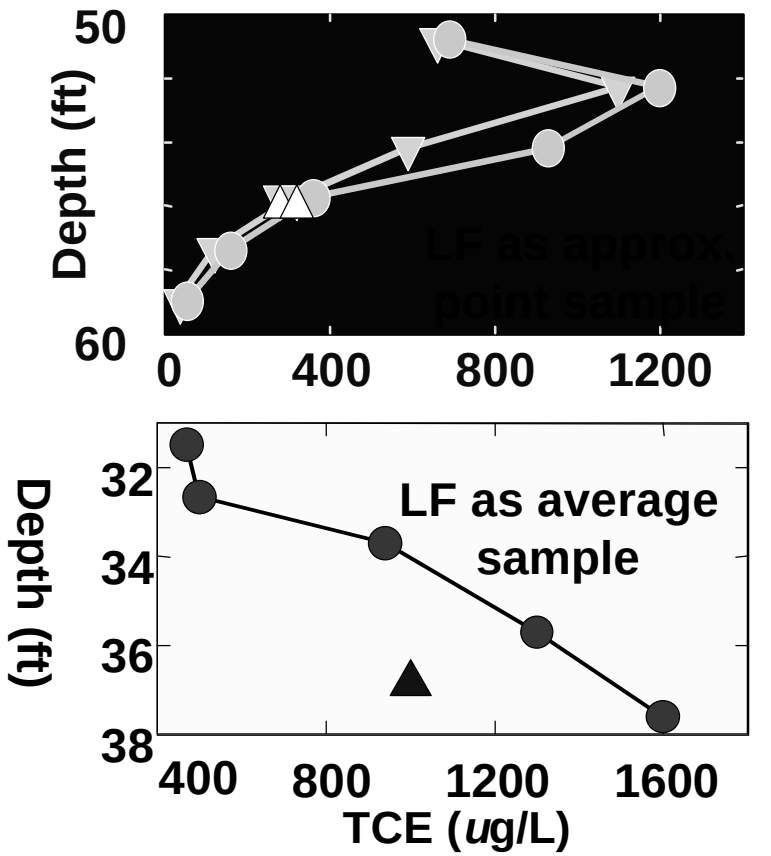
- If the goal is to determine and monitor higher concentrations or to examine contaminant stratification within the screened interval
  - PDB samplers may be appropriate
- If the goal is to determine the average concentrations for the entire screened interval
  - An average of multiple PDB samplers may be appropriate.
  - A pumped sample may produce an average concentration across the screened interval, but several field tests suggest that low-flow samples sometimes constitute approximate point samples and sometimes constitute an average concentration over intervals that may vary from well to well

Vertical stratification of VOCs

- In areas where vertical stratification of VOCs is anticipated, using multiple PDB samplers may more fully characterize the contaminated horizon than using a single PDB sampler.
  - Particularly true in well screens 10 ft or longer, but significant VOC stratification has been observed in intervals less than 5 ft
- Because of the influences of chemical and hydraulic heterogeneity, discussed earlier, it is advisable that both the vertical distribution of VOCs and the potential for intra-borehole flow be determined in wells having screens longer than 10 ft.

Comparisons of PDB samplers to conventional methodologies

- Resulting concentrations may differ because each methodology is sometimes influenced in different ways by aquifer hydraulic and chemical heterogeneity
  - PDB sampler: typically an approximate point sample
  - 3-Casing-volume purge-and-sample: integrates water over a relatively large area
  - Low-flow sampling: Sometimes an approximate point sample and other times an average concentration over a larger area.



Quality control and assurance

- At least 10 percent replicate samples are recommended.
- Tests should be done on the water used to fill the PDB sampler. Some VOCs introduced in the fill water (such as acetone) may not readily diffusion out of the bag, leading to a potential false positive.
- Trip blanks sometimes can be used to determine whether contaminants have affected the samplers prior to deployment
- Trip blanks should be collected at time of deployment

Regulatory Aspects of Passive Diffusion Bag Samplers

- Regulatory Consideration / Requirements
  - Regulatory requirements specific to diffusion samplers have not been identified
  - Technical performance of the Diffusion Sampler is the key issue (this is technical not regulatory)
- Regulatory Acceptance
  - Summary of State experience

PDB Sampler Perception

- Focus – A Different Sample Collection Method

  Once the PDB Sampler is retrieved from the well, all other sampling issues (I.e., sample containers, preservation, chain of custody, analysis, etc….) are identical to conventional sampling methodologies

Applicability

- Recommended for long term monitoring at well characterized sites
- COCs match PDB sampler capability?
- Due to inability to detect iron, sulfate, nitrate, and manganese, PDBS currently not recommended for evaluation of Natural Attenuation processes

  [note: PDB samplers can detect DO, Methane, and breakdown prod]

Deployment

- Important to accurately measure sampler position in well
- “As built” well diagrams important
- Minimum 2-week equilibration period
- Field studies did not identify problems in leaving samplers in well for 3 months

Performance Evaluation

- Simple site conditions – comparison to historic data acceptable
- More complicated site conditions: side-by-side comparisons appropriate
- Poor correlation DOES NOT indicate failure
- Identify and agree upon evaluation criteria before deployment

Future Work for ITRC Diffusion Sampler Team

- Track Sampler Performance – post results on ITRC website (www.itrcweb.org)
  - Use of vapor phase diffusion samplers in sediments
  - New approach for passive sampling of inorganics
- Post information on technology advances and lessons learned at www.itrcweb.org
- Act as information resource to regulators and stakeholders regarding PDB samplers

Question & Answers

Helpful Hint:
Securely
Attach the Line
at the Well
Head

For more information on ITRC training opportunities visit:
www.itrcweb.org

Thank you for attending this ITRC training course.

Thank You!

Links to Additional Resources